

General Electric Systems Technology Manual

Chapter 10.0

Emergency Core Cooling Systems

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10.0 EMERGENCY CORE COOLING SYSTEMS

Introduction:

The purpose of the Emergency Core Cooling Systems (ECCSs) is to provide core cooling under Loss Of Coolant Accident (LOCA) conditions to limit fuel cladding damage and therefore limit the release of radioactive materials to the environment.

The ECCS, shown in Figure 10.0-1, consists of two high pressure systems and two low pressure systems. The high pressure systems are the High Pressure Coolant Injection (HPCI) System and the Automatic Depressurization System (ADS). The low pressure systems are the Low Pressure Coolant Injection (LPCI) mode of the Residual Heat Removal (RHR) System and the Core Spray (CS) System.

Acceptance Criteria:

Emergency core cooling systems are designed to prevent melting and fragmentation of the cladding for any LOCA within the design basis spectrum. The objectives of these systems are to keep the cladding and fuel from distorting to a degree that subsequent cooling would be ineffective. Satisfying these criteria does allow for the tolerance of cladding perforation. Even though the cooling equipment is successful in keeping cladding temperature below the 2,200°F limit, a small percentage of the fuel may perforate. However, the occurrence of even a large number of perforations does not prevent effective core cooling.

Cladding is perforated when the gas pressure within the rod exceeds the pressure the cladding can withstand for that particular cladding temperature. The perforation is local, in that a given fuel rod perforates at a particular location on the order of an inch in axial length. The perforation usually occurs, and is localized, at a weak point along the fuel rod length, probably at a point of cladding flaw, pellet chip, or slightly increased cladding oxidation. Such weak points are randomly distributed among the fuel rods within the fuel assembly.

The conclusion that the perforation is random and local is based on confirmed observations of irradiated fuel. Such random failures have also been demonstrated in test loops by placing zircalloy tubing, filled with UO₂ pellets and pressurized with gas, in an induction heating facility. The observed failures were always localized and random along the length of the heated rod. Only a slight change in diameter was observed, except within an inch or two on either side of the perforation. This is characteristic of high temperature burst failures in general. From these tests, the major conclusions are that perforations are indeed local and that the fuel rods do not grossly distort over the length of the fuel rod.

The ECCS acceptance criteria for light water reactors, which are listed in 10 CFR 50.46, are discussed in the paragraphs which follow.

Design Criteria:

The ECCS is designed to provide protection against postulated LOCAAs caused by ruptures in primary system piping. In addition to satisfying the ECCS acceptance criteria the ECCS is designed to meet the following requirements:

- Provide for any primary line break up to and including the double ended break of the largest line.
- Provide two independent phenomenological cooling methods (flooding and spraying).
- Provide a high pressure cooling system capable of maintaining water level above the top of the core and preventing ADS actuation for small line breaks.
- No operator action is required for 10 minutes.
- Provide a sufficient water source (and necessary piping, pumps, and other hardware so that the containment and reactor vessel core can be flooded for heat removal.)
- No single active component failure in the ECCSs shall prevent automatic initiation and successful operation.
- Long term (10 minutes) cooling requirements.
- Provide on site emergency power.
- Provide shedding of non ECCSs loads.
- All active components shall be testable.

10.0.1 High Pressure Coolant Injection System (Section 10.1)

The High Pressure Coolant Injection System maintains adequate reactor vessel water inventory for core cooling on a small break LOCA, depressurizes the reactor vessel to allow the low pressure ECCSs to inject on an intermediate size LOCA, and backs up the function of the Reactor Core Isolation Cooling (RCIC) System (Section 2.7) during reactor vessel isolation conditions.

10.0.2 Automatic Depressurization System (Section 10.2)

The Automatic Depressurization System depressurizes the reactor vessel so that the low pressure ECCSs can inject water into the reactor vessel following small or intermediate size break LOCAAs concurrent with HPCI System failure.

10.0.3 Core Spray System (Section 10.3)

The Core Spray System provides spray cooling to the reactor core to help mitigate the consequences of a large break LOCA when reactor pressure is low enough for the system to inject water into the reactor vessel.

10.0.4 Low Pressure Coolant Injection System (Section 10.4)

The LPCI mode of RHR restores and maintains water level in the reactor vessel following a large break LOCA when reactor pressure is low enough for the system to inject water. The RHR System has several other operational modes, some of which are safety related and some which are not. Each mode is described in Section 10.4.

10.0.5 ECCS Wrapup (Section 10.5)

The ECCS Wrapup provides an overview of the ECCS systems, the Design Basis Accident-LOCA (DBA-LOCA), 10CFR General Design Criteria, and the ECCS Acceptance Criteria. These and the timeline of the events occurring during the DBA-LOCA are discussed.